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Indian Standard

SPECIFICATION FOR LAMPS FOR LIGHTING ON BOARD SHIPS

(First Revision)

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Indian Standard
SPECIFICATION FOR LAMPS FOR LIGHTING ON BOARD SHIPS
(First Revision)

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Indian Standard

SPECIFICATION FOR LAMPS FOR LIGHTING ON BOARD SHIPS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 24 January 1980, after the draft finalized by the Electric Lamps and Accessories Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard was first published in 1964. The important changes in this revision are the modification of vibration test and extention of Table 1 to cover more lamps used in ships.

0.3 A large variety of lamps is being used on board ships, both merchant and navy ships, for general illumination and lighting purposes. This standard has been prepared with a view to reducing the multiplicity of such lamps and facilitating interchangeability.

0.4 The important requirement of a lamp for use on board ships is its ability to function satisfactorily on the system voltage standardized for the ships under the severe conditions prevalent at sea, both climatic and mechanical.

0.4.1 The lamps covered by this specification should necessarily be of reinforced filament construction capable of withstanding the mechanical shock and vibration occurring in normal operation on ships. In the absence of definite information about mechanical shock, no requirements relating to mechanical shock have been specified. Taking into consideration the different vibration requirements, an empirical and accelerated vibration test has been introduced. Experience has proved that lamps passing the accelerated vibration test withstand the rough sea conditions more satisfactorily than the lamps that are not checked for this vibration requirement.

0.4.2 The highly corrosive and damp saline atmosphere, also causes frequent failure of lamps on board ships. Corrosion effects may be reduced to a large extent by the nickel plating of the cap as specified in this standard. The effect of saline and damp atmosphere on the cementing material of lamp cap is under consideration.

0.5 In order to standardize the rated voltages of the lamps, the characteristics of the lamps have been specified at 115, 127 and 230 volts. Although 110 and 220 volt lamps are also being used presently in the ships, it was considered that the requirements for these lamps would be covered by 115 and 230 V lamps respectively. 127 volt has been specified in the standard as non-preferred voltage and the ultimate intention of the committee is to delete this voltage in due course and standardize the characteristics of lamps on two voltages only namely, 115 and 230 volts.

0.6 In the preparation of this standard, assistance has been derived from the following:

IN Schedule EE/95 Specification for electric lamps upto and including 50 volts and over 50 volts. Director of Stores Production (Navy), Ministry of Defence (CGDP), Government of India.

Defence Specification DEF/133 (February 1963) Climatic, shock and vibration testing of service equipment. Ministry of Defence, UK.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the technical requirements and methods of tests for tungsten filament incandescent lamps for general lighting purposes in ships having a nominal life of 1 000 hours, rated wattage of 25 to 500 W, rated voltages of 115 V, 127 V and 230 V; and clear, internally frosted or natural coloured bulbs; with standard bayonet or Edison screw caps.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Type — Denotes lamps of the same general construction, irrespective of the type of cap, which are intended to be identical in photometric and electrical ratings.

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*Rules for rounding off numerical values (*revised*).

2.2 Batch — All the lamps of one type put forward in a lot at one time for acceptance or all the lamps of one type which are subjected, on one occasion, to test for compliance with this standard.

2.3 Test Quantities

2.3.1 *Inspection Test Quantity* (*ITQ*) — The number of lamps selected from a batch according to an agreed method, the tests on which shall determine whether or not the batch complies with the mechanical and physical requirements specified in **4.1** and marking requirements specified in **5**.

2.3.2 *Rating Test Quantity* (*RTQ*) — The number of lamps selected from a batch according to an agreed method, the initial rating tests on which shall determine whether or not the batch complies with the initial rating requirements specified in **4.2**.

2.3.3 *Life Test Quantity* (*LTQ*) — The number of lamps selected from a batch according to an agreed method, the life test and measurements for lumen maintenance on which shall determine whether or not the batch complies with the life performance requirements specified in **4.3**.

2.4 Light Centre Length — The distance from the geometrical centre of the filament to a specified position on the lamp cap.

2.5 Lumen — The lumen is the unit of luminous flux. It is equal to the flux emitted in a solid angle of one steradian by a uniform point source having an intensity of one candela.

NOTE — The candela (abbreviation: cd) is the unit of luminous intensity. It is of magnitude such that the luminance of a full radiator at the temperature of solidification of platinum is 60 units of luminous intensity per square centimetre.

2.6 Initial Readings — The photometric and electrical measurements made at the end of the ageing period.

2.7 Life — The life of a lamp is the number of hours it operates to ‘ burn out ’ or to any other criterion of life performance laid down in this standard.

2.8 Rated Voltage — The voltage marked on the lamp.

2.9 Rated Wattage — The wattage marked on the lamp.

2.10 Ageing — The operation of a new lamp for a specified period in order to stabilize its electrical and photometric characteristics before initial readings are taken.

3. CHARACTERISTICS OF LAMPS

3.1 The rated voltage, wattage, lumens, cap designations, dimensions and the finish of lamps shall be as specified in Table 1.

4. REQUIREMENTS

4.1 Mechanical and Physical Requirements

4.1.1 *Bulbs* — The bulbs shall comply with the requirements laid down in IS : 1112-1957*. The bulbs may be frosted internally or natural coloured when so specified.

4.1.1.1 *Coloured bulbs* — In addition to conforming to the requirements of **4.1.1**, coloured bulbs shall be of best quality, naturally transparent coloured glass of red shade.

4.1.2 *Caps* — The dimensions of caps shall be in accordance with IS : 9206-1979†.

4.1.2.1 The shells of the caps shall be fabricated from brass and nickel-plated to a thickness of 0·015 mm (corresponding to Service Grade 4 of IS : 4827-1968‡).

4.1.3 *Attachment of Caps to Bulbs* — Caps shall be attached to the bulbs so strongly as to comply with the torsion test carried out in accordance with **7.3** with a torsional moment of 3 Nm both during the inspection tests and at the end of life test.

4.1.4 *Insulation Resistance of Bayonet Caps* — Insulation resistance between the lamp contacts and the shell of bayonet cap in a dry condition, when measured in accordance with **7.4**, shall be not less than 50 MΩ.

4.1.5 *Dimensions of Lamps* — Dimensions of lamps shall be in accordance with Table 1.

4.1.6 *Solder* — The solder shall not prevent proper engagement of the cap in the holder.

NOTE — It is not essential that the whole surface of the eyelet should be covered with solder, provided there is good electrical contact between the lead-in wire and the eyelet, and the projecting portion of the wire above the solder should not be more than 1 mm.

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*Specification for glass shells for general lighting service lamps.

†Dimensions of caps for tungsten filament general service electric lamps.

‡Specification for electroplated coatings of nickel and chromium on copper and copper alloys.

4.2 Initial Rating Requirement

4.2.1 Initial wattage of individual lamps shall not exceed the values given in Table 1.

4.2.2 Nominal light output in lumens of individual lamps shall be not less than the values given in Table 1.

NOTE — Requirements of colour characteristics of red coloured lamps are under consideration.

4.3 Life Performance Requirements — The average life, individual lamp life and the individual lumen at 750 hours shall comply with the requirements specified in **4.3.1** and **4.3.2**.

4.3.1 *Average Life* — Average life shall be not less than 1 000 hours, subject to the following allowances:

Number of Lamps in Life Test	**Percentage Allowance in Average Life (Hours)*
13	12
14 to 16	11
17 „ 19	10
20 „ 22	9
23 „ 25	8

4.3.2 *Individual Lamp Requirement* — A lamp shall have:

a) a life not less than 700 hours subject to the qualifying limits specified in **8.4**(b); and

b) lumens at 750 hours shall be not less than 85 percent of its initial lumen value except:

   1) for 115 V, 25 W lamps, the limit shall be 78 percent; and

   2) for 230 V, 25 W lamps, the limit shall be 82 percent.

NOTE — If a lamp does not comply with (b) above, it shall be considered to have failed at 690 hours.

5. MARKING

5.1 Lamps shall be distinctly and indelibly marked as specified in **5.1.1** to **5.1.3**.

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*These figures are statistical allowance to take into account the relatively small sizes of the samples taken for life tests.

TABLE 1 LAMPS FOR USE ON BOARD SHIPS

(*Clauses* 3.1, 4.1.5, 4.2.1 *and* 4.2.2)

RATING		CAP DESIGNATION	FINISH	OVERALL LENGTH, *Max*	BULB DIAMETER, *Max*	LIGHT CENTRE LENGTH	INITIAL WATTS, *Max*	MINIMUM LUMENS
Voltage	Wattage							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
V	W							
115	25	B22/25 × 26	IF or clear	110	62	To be declared by the manufacturer ± 3 mm Tolerances	26·5	190
230	25	B22/25 × 26	IF or clear	110	62		26·5	175
115	40	B22/25 × 26 or E27/27	IF or clear	110	62		42·1	350
127	40	E27/27	IF or clear	110	62		42·1	330
230	40	B22/25 × 26 or E27/27	IF or clear	110	62		42·1	290
115	60	B22/25 × 26 or E27/27	IF or clear	110	62		62·9	530
230	60	B22/25 × 26 or E27/27	IF or clear	110	62		62·9	505
115	100	B22/25 × 26 or E27/27	IF or clear	110	62		104·5	1 200
127	100	E27/27	IF or clear	110	62		104·5	1 150
230	100	B22/25 × 26 or E27/27	IF or clear	110	62		104·5	1 100
127	200	E27/27	IF or clear	190	81		208·5	3 200
230	200	E27/27	IF or clear	236	81		208·5	2 900

127	300	E27/27 or E40/45	IF or clear	236	112	180 ± 5	312·5	4 950
230	300	E40/45	IF or clear	240	112	180 ± 5	312·5	4 250
127	500	E40/45	IF or clear	240	112	180 ± 5	520·5	8 900
230	500	E40/45	IF or clear	275	135	180 ± 5	520·5	8 250

IF — Internally frosted.

NOTE 1 — The lamps may be supplied in *G* Red or *D* Red finish if agreed between the purchaser and the supplier.

NOTE 2 — 127 V is the non-preferred voltage and will be deleted in due course.

5.1.1 *On the Bulb* — The following information shall be marked on the bulb:

a) Mark of the manufacturer,
b) Rated volts (marked ' V ' or ' volts '),
c) Rated watts (marked ' W ' or ' watts '), and
d) Country of manufacture.

5.1.2 *On the Lamp Cap* — The following information shall be marked on the lamp cap:

The letter ' S ' to indicate that these lamps are for ship lighting.

5.1.3 *On the Carton* — The following information shall be marked on the carton of each lamp:

a) The information given in **5.1.1**, and
b) Any other information as agreed between the supplier and the purchaser.

5.2 The lamps may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

6. SELECTION OF LAMPS FOR TESTS (SAMPLING)

6.1 Samples for testing shall be selected at random from lamps belonging to one batch.

6.1.1 *Batch Consisting of 1 000 Lamps or Less* — For batches consisting of 10 or less containers, lamps shall be selected at random from every container. If the batch consists of more than 10 containers, lamps shall be selected from at least one half of the total number of containers in the batch with a minimum of 10 containers.

6.1.2 *Batch Consisting of More Than 1 000 Lamps* — Lamps shall be selected at random, as far as possible, from one-third of the total number of containers in the batch, with a minimum of 10 containers.

6.2 Inspection Test Quantity — Inspection test quantity (ITQ) shall consist of 5 percent of the batch with, however, a minimum of 35 and a maximum of 70 lamps.

6.3 Rating Test Quantity — Rating test quantity (RTQ) selected at random from the lamps which have passed the inspection tests, shall consist of not less than 25 lamps and not more than 50 lamps.

6.4 Life Test Quantity — Life test quantity (LTQ) selected at random from the lamps which have passed the rating tests, shall consist of not less than 15 lamps, and not more than 25 lamps.

7. TESTS

7.1 Conditions of Tests

7.1.1 *Position of Burning* — Lamps shall burn in a vertical position with cap up.

7.1.2 *Ageing* — Before the lamps are subjected to photometric tests for the first time, they shall be aged for a period of approximately 1 hour at the rated voltage.

7.1.3 *Test Voltage* — Lamps shall be tested at their rated voltage.

7.2 Visual Examination and Checking for Mechanical and Physical Requirements — Each lamp of ITQ shall be examined visually as well as checked for physical and mechanical requirements detailed in **4.1** and marking requirements specified in **5.**

7.3 Torsion Test

7.3.1 The lamps selected for torsion test shall be tropically conditioned as given in **7.3.1.1** to **7.3.4**.

7.3.1.1 The lamps under test shall be placed in a humidity chamber operated at a temperature of 60°C and a relative humidity of 90 percent.

7.3.1.2 These conditions shall be maintained for 16 hours and the chamber then allowed to cool to normal room temperature in not less than 8 hours.

7.3.1.3 This cycle shall be performed three times, the lamps not being removed until after 6 hours of cooling in the third cycle. They shall then be wiped dry and left for one hour in room conditions.

7.3.2 Lamps shall be inserted in a holder (*see* Appendix A) and fixed to a suitable torsion testing machine.

7.3.3 The test shall then be carried out by twisting the bulbs. The torque shall not be applied suddenly, but increased gradually to the moment specified in **4.1.3**.

7.3.4 This test shall be carried out during inspection test and after life test (*see* **7.6**).

7.4 Insulation Resistance of Bayonet Caps — The insulation resistance between cap-shell and contacts shall be measured before ageing. Before testing, the lamps shall be removed from their wrappers, stored in dry surroundings for not less than 48 hours and the external surface of their insulation shall be wiped with a dry cloth. In case the insulation, when first measured, is found to be insufficient, the lamps shall be stored in a warm, dry atmosphere for a week and then re-tested for insulation.

7.4.1 Insulation resistance shall be measured with 500 volts dc applied for a period of 1 minute.

7.5 Initial Rating Tests — Measurements shall be made for initial watts and initial lumens at the test voltage with a suitable photometric integrator (*see* IS : 2407-1963*). The accuracy of the voltmeter and ammeter, when used for the test, shall be not less than 0·2 and 0·3 percent respectively of full scale readings.

NOTE — Measurement of colour characteristics for the red coloured lamps is under consideration.

7.6 Life Test

7.6.1 The voltage applied shall be the test voltage (*see* **7.1.3**) or by agreement a selected voltage between 100 percent and 110 percent of the test voltage. It shall be kept within ±1 volt for the higher voltage group and within ±0·5 volt for the lower voltage group during the life test. The equivalent life at test voltage shall be determined in accordance with the following equation:

$$L_0 = L\left(\frac{U}{U_0}\right)^n$$

where

L_0 = life at rated voltage,
L = life at test voltage,
U_0 = rated voltage,
U = average effective voltage during life test, and
n = 13 for vacuum lamps and 14 for gas-filled lamps.

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*Specification for photometric integrators.

The lamps shall be tested on alternating current supply having a nominal frequency of 50 Hz.

NOTE — In general, testing at a voltage in excess of the test voltage is done mainly for reasons of economy.

7.6.1.1 *Voltage control* — The momentary fluctuations of the test voltage during life test shall not exceed ±1 percent, and the mean effective value of the test voltage during the life test shall be taken for the calculation given in **7.6.1**. The voltage shall be free from perceptible flicker.

NOTE — Mean effective value of the voltage shall be obtained by a suitable V^2 meter (*see* Appendix B).

7.6.2 *Switching 'On' and 'Off' During Life Test* — Lamps on life test shall be switched off twice during every 24 hours of burning for periods of not less than 15 minutes, such periods not being considered as part of the life of the lamp.

7.6.3 *Accidentally Broken Lamps* — If one or more lamps break accidentally in handling during life test, the life test results may be computed on the basis of results obtained on the remainder of the LTQ, provided the number of the latter is not less than 13.

7.6.4 *Measurements for Lumens at 750 Hours* — Each lamp of the LTQ shall be tested for lumens with a photometric integrator at the test voltage at 750 ± 24 hours (or its equivalent, if forced testing is used).

7.6.5 *Termination of Test* — The life test shall be considered to have terminated at 1 250 hours, or its equivalent, if forced testing is used.

7.7 Vibration Test

7.7.1 The lamps shall be capable of withstanding resonance search and vibration endurance tests as specified in **7.7.2** and **7.7.3** when mounted on a vibration machine complying with Appendix C.

7.7.1.1 *Number of lamps* — A manufacturer, before proceeding with bulk production of bayonet cap or Edison Screw Lamps shall provide, as relevant, the following vibration test quantities for type approval testing:

Bayonet cap lamps	20 samples
Edison screw cap lamps	20 samples

7.7.1.2 To assist in the observation of resonance, which may occur in the lamp filaments and supports, the lamps submitted for the tests shall possess clear glass envelopes but shall otherwise be identical in design with the lamps of the intended production run.

7.7.1.3 *Position of operation* — The lamps provided for type approval tests shall be mounted on a test rig similar to that shown in Fig. 1. Mounting in three positions shall be arranged as given below:

a) 12 Lamps	Vertically, cap up
b) 4 Lamps	Vertically, cap down
c) 4 Lamps	In horizontal position

The lamps shall be subjected to resonance search and vibration endurance tests with the test rig secured directly to the vibration testing machine.

7.7.1.4 *Ageing* — Before vibration tests are performed the lamps shall be aged under life test conditions for a period of 200 hours. Any lamp which fails during ageing shall be replaced. The ageing of the spare lamps is, therefore, recommended.

7.7.1.5 *Test voltage* — The test voltage for the lamps when tested in the operating condition shall be the rated voltage. The electrical supply shall be alternating current with a nominal frequency between 40 Hz and 60 Hz.

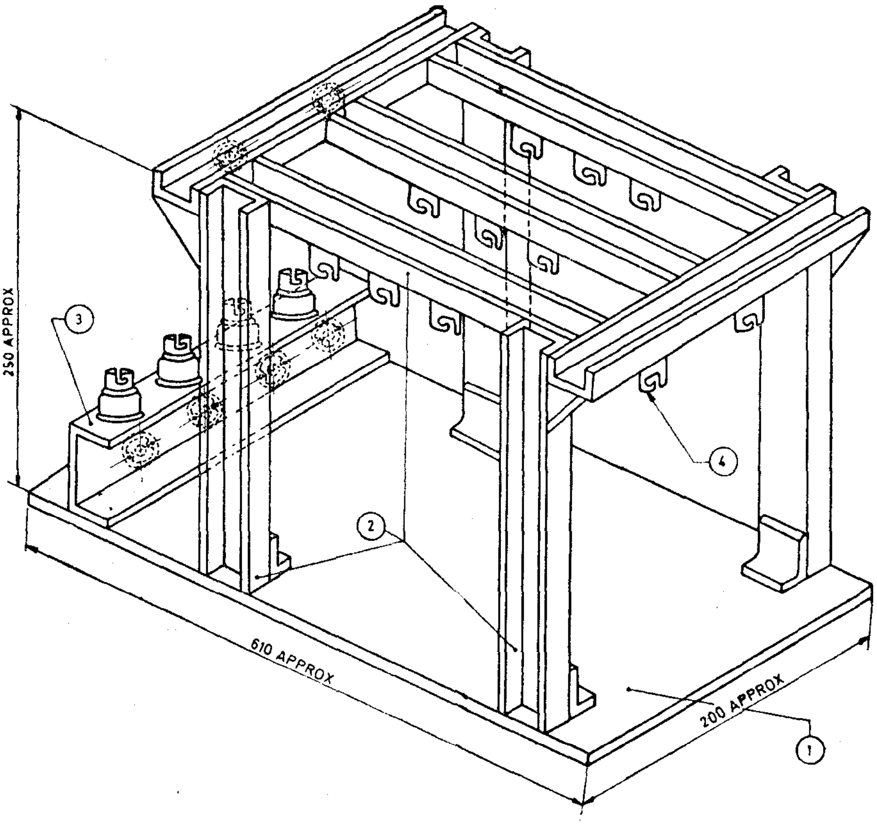
7.7.1.6 *Frequency range and amplitude* — The lamps shall be tested at the ranges of frequency and steps of amplitude as given in the following table:

Frequency Hz	*Amplitude* mm
0 to 14	±1·27
14 to 23	±0·46
Over 23 to 40	±0·13

7.7.2 *Resonance Search Test*

7.7.2.1 The lamps shall be subjected to the following test in the cold or ‘ off ’, condition and the test shall be repeated with the lamps switched ‘ on ’.

7.7.2.2 The frequency shall be varied continuously over the range and amplitudes specified in **7.7.1.6**, the rate of change not normally exceeding one octave in 2 minutes so that resonance can be easily detected.



NOTE 1 — Lamps are to be locked to lampholders by a suitable locking ring or other device during vibration tests to compensate for variable characteristics which may exist in the lampholders.

NOTE 2 — The channel members are to be adequately welded to form rigid structure which shall then be welded to the base plate and no observable resonance below 50 Hz shall exist in the test rig.

NOTE 3 — The test rig shall be secured to the vibration table through the suitable fixing holes drilled in the base plate so as to match that of the vibration table holes.

NOTE 4 — A separate rig of similar design, but fitted with Edison Screw Lamp holders shall be used for the testing of Edison screw cap lamps.

Weight approx = 32 kg

1. Base plate mild steel
2. 51 × 25 mm Mild steel channel
3. 102 × 51 mm Mild steel channel
4. Lampholders

FIG. 1 SCHEMATIC ARRANGEMENT FOR 20 LAMP VIBRATION TEST RIG

7.7.2.3 Resonance may be observed by a stroboscope or by other means, wherever possible the maximum amplitude should be approached progressively to avoid damage to the lamps.

NOTE — To observe a resonance when the lamps are 'on' it will be necessary to view the lamps through a suitable smoked glass filter or apply an approved method by which an image of the lamp filament is projected as to an adjacent screen.

7.7.2.4 Resonance should be removed wherever possible by modification to the design of the lamp.

7.7.2.5 At the conclusion of the test no damage due to resonance shall have been found and the lamps shall be capable of fulfilling all specified requirements.

7.7.3 *Vibration Endurance Test*

7.7.3.1 The lamps shall first be tested for 1 hour at the frequency amplitude and the condition of each non-removable resonance. A test of 18 hours duration shall then be performed as follows:

a) *With the lamps 'off'* — 2 hours at each of the frequencies and amplitudes stated in **7.7.1.6.**

b) *With the lamps 'on'* — 4 hours at each of the frequencies and amplitudes stated in **7.7.1.6.**

7.7.3.2 Where a non-removable resonance has been noted at one of the above frequencies, the test shall be performed at the nearest lower frequency at which the resonance is not apparent. At the conclusion of the test the lamps shall be capable of fulfilling all specified requirements.

8. CONDITIONS OF COMPLIANCE

8.1 General — If any test quantity fails to satisfy any of the requirements of **8.2** to **8.5**, the batch shall be rejected and no subsequent tests shall be carried out from the batch (*see also* Appendix D.).

8.2 Mechanical and Physical Requirements and Marking — A batch shall be considered to comply with the requirements of **4.1** and **5**, if the number of lamps failing does not exceed the qualifying limits given below:

Test Quantity	*Qualifying Limit*
	For any single requirement
35 to 50	3
51 ,, 70	4

Test Quantity	*Qualifying Limit*
For all requirements taken together	
35 to 44	5
45 „ 56	6
57 „ 70	7

8.3 Initial Ratings — A batch shall be considered to comply with initial rating requirements (*see* **4.2**) if the number of lamps failing does not exceed the qualifying limits given below:

Test Quantity	*Qualifying Limit*
For initial wattage of individual lamps	
25 to 33	5
34 „ 41	6
42 „ 50	7
For initial lumens of individual lamps	
25 to 33	5
34 „ 41	6
42 „ 50	7
For initial wattage and initial lumens of individual lamps taken together	
25 to 28	6
29 „ 35	7
36 „ 41	8
42 „ 48	9
49 and 50	10

8.4 Life Performance — A batch shall be considered as complying with life performance requirements (*see* **4.3**), if:

a) the average life of the life test quantity attains the value specified in **4.3.1** subject to the allowance specified therein, and

b) the number of lamps failing in respect of individual life and lumens of individual lamps at 750 hours (*see* **4.3.2**) does not exceed the qualifying limits below:

Test Quantity	*Qualifying Limit*
13	3
14 to 20	4
21 „ 25	5

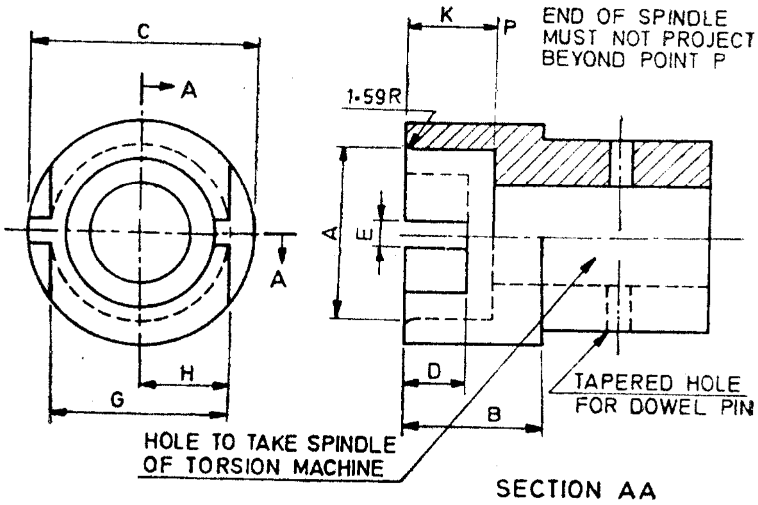
8.5 Vibration Performance — A bath shall be considered to comply with vibration performance if not more than 2 lamps out of the vibration test quantity of 20 lamps fail to satisfy the vibration test as specified in **7.7**.

APPENDIX A

(*Clause* 7.3.2)

HOLDERS FOR TORSION TEST

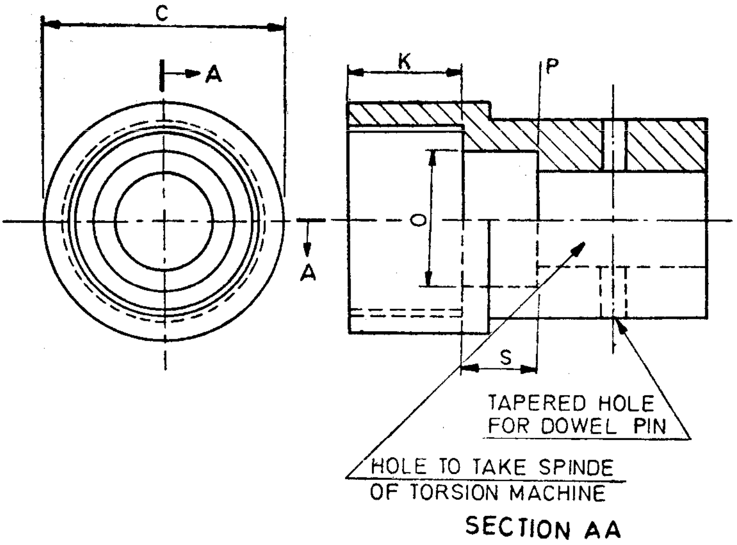
A-1. The dimensions of holders for torsion tests of the different lamp caps shall be as given in Fig. 2 and 3.


C
A
A
G
H
K
P
END OF SPINDLE MUST NOT PROJECT BEYOND POINT P
1·59R
A
E
D
B
TAPERED HOLE FOR DOWEL PIN
HOLE TO TAKE SPINDLE OF TORSION MACHINE
SECTION AA

Ref Letter	Dimension	Tolerance
A	22·17	+0·03
B	19·05	±0·3
C	28·57	±0·3
D	9·52	±0·3
E	3·00	+0·17
G	24·61	±0·3
H	12·30	±0·3
K	12·70	±0·3

All dimensions in millimetres.

Fig. 2 For Bayonet Cap B22


C
A
A
K
P
O
S
TAPERED HOLE FOR DOWEL PIN
HOLE TO TAKE SPINDE OF TORSION MACHINE
SECTION AA

REF LETTER	DIMENSION		TOLERANCE
	E27	E40	
C	33·02	47·62	±0·3
K	10·92	19·05	±0·3
O	23·01	34·04	±0·3
S	11·68	12·95	±0·3

All dimensions in millimetres.

FIG. 3 FOR SCREW CAPS E27 AND E40

APPENDIX B

(*Clause* 7.6.1.1)

BRIEF DESCRIPTION OF V^2 METER

B-1. The V^2 meters are based on the same principle as the normal single phase induction kilowatt-hour meters. The difference is that a fine-wired coil in series with a high resistance has been substituted for the normal current coil. This coil as well as the normal voltage coil are both connected in parallel to the mains.

B-2. As the speed of the rotation of the disc is proportional to the voltage on the voltage coil and the current in the current coil, and as the latter is proportional to the voltage, with the built-in resistance constant, the speed of rotation of the disc is proportional to the square of the voltage. Hence the reading per unit of time is proportional to the square of the voltage.

B-2.1 The measurement of the time is done by a clock-work starting and stopping with voltage on and off. If the clock-work is of the synchronous type, it should be ensured that the frequency is correct. If it is of the electrically worked self-starting type with a balance, it should be compared with a normal good watch adjusted in the normal way.

B-3. The accuracy of the V^2 meter depends on the steadiness of the voltage used. The accuracy is generally about 0·25 percent when the voltage used is within ±1 percent. In this respect the V^2 meter is more accurate than any recording voltmeter the accuracy of which is mostly not greater than 2 percent of the full-scale value.

APPENDIX C

(*Clause* 7.7.1)

VIBRATION TESTING MACHINES

C-0. GENERAL

C-0.1 The information given in this appendix outlines the basic requirements for vibration machine to be used for carrying out vibration test in accordance with this standard.

C-1. REQUIREMENTS

C-1.1 The motion of the vibration machines shall be sinusoidal. The acceleration wave-form shall, as far as is practicable, be clean, being free from harmonic or other distortion.

C-1.2 Vibration in directions other than the plane in which the test is being made shall be kept to a minimum.

C-1.3 The amplitude of the vibrating platform shall be adjustable as required by the test specification. For circular vibrators adjustment shall be possible in the two planes.

C-1.4 The vibration platform and any jigs used for attachments shall be sufficiently rigid to avoid introducing wave-form or amplitude distortion over the frequency range of the test.

C-1.5 The vibration platform shall have sufficient mass to prevent any dynamic responses within the equipment under test affecting the performance of the table.

C-2. SUITABLE MACHINES

C-2.1 A wide range of vibration machines is available having a performance depending upon their design features. In general, vibration machines may be divided into following two groups:

- a) Mechanical drive machines mainly of the forced eccentric type, and
- b) Electromagnetic machines.

C-2.1.1 The main features in each group may be characterized as follows:

- a) Mechanical machines:
  - 1) limited to low frequency application up to a maximum of 150 Hz;
  - 2) may be made with a large table and large load capacity;
  - 3) generally possess heavy and rigid tables;
  - 4) generally have pre-set amplitude displacement adjustment, and are not adjustable whilst running; and
  - 5) wave-form can vary from good to poor.
- b) Electromagnetic machines:
  - 1) Wide frequency range with upper limit between 1 000 c/s and 10 000 c/s depending upon size of machine;
  - 2) The amplitude is adjustable even whilst running;
  - 3) Are suitable for automatic amplitude and frequency control;
  - 4) Wave-form is good at low frequencies up to approximately 1 000 Hz deteriorating at high frequencies;
  - 5) The test platform is usually small and the moving system has low mass; and
  - 6) The small test platform means that elaborate jigging is required when testing large equipment.

APPENDIX D

(*Clause* 8.1)

STATISTICAL BASIS OF TEST QUANTITIES AND CONDITIONS OF COMPLIANCE

D-1. The acceptance limits given under **8.2**, **8.3** and **8.5** are such that there is at least a 0·975 (39 out of 40) probability of compliance provided that the bulk of the manufacturers' production contains:

a) Not more than 2 percent failing any single requirement under **4.1** and **5** and not more than 5 percent failing the requirements combined,

b) Not more than 7 percent failing the requirements for initial ratings when each is taken separately and not more than 10 percent when these requirements are combined, and

c) Not more than 8 percent failing the individual life at 700 hours and lumen requirements at 75 percent of nominal life.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Unit

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Defi
Force	newton	N	1 N =
Energy	joule	J	1 J =
Power	watt	W	1 W =
Flux	weber	Wb	1 Wb =
Flux density	tesla	T	1 T =
Frequency	hertz	Hz	1 Hz =
Electric conductance	siemens	S	1 S =
Electromotive force	volt	V	1 V =
Pressure, stress	pascal	Pa	1 Pa =

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